ELECTRONICS CABINET WITH AN AIR-TO-AIR HEAT EXCHANGER MOUNTED TO THE OUTSIDE OF THE CABINET

BACKGROUND OF THE INVENTION

1. Field of the Invention.

The present invention relates to electronics cabinets and, more particularly, to an electronics cabinet with an air-to-air heat exchanger mounted to the outside of the cabinet.

2. Description of the Related Art.

Telecommunication equipment is commonly housed in electronics cabinets that sit outside in residential and commercial neighborhoods. The cabinets are water tight and air tight to prevent water and dust from entering the cabinets and reducing the useful life of the equipment inside the cabinets.

FIG. 1 shows a perspective view that illustrates a prior-art electronics cabinet 100. As shown in FIG. 1, cabinet 100 includes a base plate 110, a top plate 112, and a number of side walls 114 that are connected to base plate 110 and top plate 112. In addition, cabinet 100 includes a rack 116 that holds telecommunication equipment, and a door 118 that is connected to the side walls 114 via hinges or other rotational means to provide access to the interior of cabinet 100.

One trend in the telecommunications industry is to make line replaceable cards such that, for example, a card that supports plain old telephone service (POTS) can be replaced with a card that supports both POTS and xDSL broadband data service. Replacement cards which

provide more than basic POTS service, however, tend to generate more heat than basic POTS cards.

Thus, as the power requirements of the replacement equipment increase, more and more heat must be removed from the enclosures where the equipment is housed. This is a particular problem for legacy electronics cabinets which were originally optimized for one heat load, but which now must manage the increased heat load that results from the replacement equipment.

Since the enclosure is air tight and water tight, heat removal must take place through a boundary surface by using, for example, a heat exchanger. For legacy electronics cabinets, a heat exchanger is typically added by designing a replacement door with the heat exchanger factory-mounted to the replacement door. A service technician then removes the original door from the legacy cabinet and mounts the new heat exchanger door in its place.

Referring again to FIG. 1, electronics cabinet 100 also includes a replacement door 118A that has a large opening formed through door 118A, and a heat exchanger 120 that sits entirely within the opening. When doors 118 and 118A are closed, base plate 110, top plate 112, and side walls 114 form an enclosure that has an air tight and water tight seal.

However, replacing an entire door for the sole purpose of adding a heat exchanger presents several problems. First, a substantial engineering effort is required to reverse-engineer a replacement door to perfectly replace the original door when the replacement door includes modifications for a heat exchanger. Further, there are scores of different legacy electronics cabinets in existence which, in turn, would each require the same substantial engineering effort.

Second, when a heat exchanger is added to the door, the heat exchanger sits within the large opening, and thereby protrudes a few centimeters (inches) into the interior of the electronics cabinet. Depending on the cabinet design, this protrusion into the interior of the cabinet can interfere with the internal equipment, complicating the design of the replacement door.

Third, replacing the door also means replacing the main seal surface for the cabinet. All electronics cabinets that house telecommunication equipment must undergo rigorous testing before deployment. Replacing the original door with a non-factory door invalidates several of the original tests. As a result, the replacement door must be re-certified to work with the electronics cabinet. The recertification, however, can be relatively expensive, and must be performed for each type of electronics cabinet.

Theoretically, rather than using a replacement door, a heat exchanger can be added to the original door in the field by a service technician. Practically, however, the process of field installing a heat exchanger in the original cabinet door is a difficult and time consuming process.

First, a very large rectangular opening must be cut out of the door, ranging from 50%-90% of the area of the door, along with dozens of mounting openings that surround the rectangular opening. Once the rectangular and mounting openings have been formed, dozens of mounting studs must then be connected to the mounting openings and the heat exchanger to complete the mechanical portion of the installation.

Thus, there is a need for an approach to removing heat from legacy electronics cabinets that does not require that the cabinet door be replaced, and can be installed in substantially less time than the time

currently required to complete a field installation of an air-to-air heat exchanger, such as heat exchanger 120.

SUMMARY OF THE INVENTION

The present invention provides an electronics cabinet that has an air-to-air heat exchanger mounted to the outside of the cabinet, and a method of installing the heat exchanger that substantially reduces the amount of time required to install the heat exchanger in the field. In accordance with the present invention, an electronics cabinet includes a bottom surface, a top surface, and a plurality of side wall surfaces that are connected to the bottom surface and the top surface.

Further, the electronics cabinet includes a door that is connected to a side wall surface, and a heat exchanger mounted to an exterior surface of the electronics cabinet. When the door is closed, the bottom surface, top surface, side wall surfaces, and door form an air tight and water tight enclosure.

The present invention also includes a method of installing a heat exchanger in an electronics cabinet. The method includes the steps of identifying a mounting region on the exterior surface of an electronics cabinet to mount the heat exchanger, and placing a template on the mounting region. The method also includes the steps of forming a first opening and a spaced apart second opening that extend through the exterior surface into an interior region of the electronics cabinet, and mounting a heat exchanger to the electronics cabinet.

A better understanding of the features and advantages of the present invention will be obtained by reference to the following detailed description and accompanying drawings that set forth an illustrative embodiment in which the principles of the invention are utilized.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view illustrating a prior-art electronics cabinet 100.

FIG. 2 is a perspective view illustrating an example of an electronics cabinet 200 in accordance with the present invention.

FIG. 3 is a perspective view illustrating an example of an electronics cabinet 300 in accordance with the present invention.

FIG. 4 is a flow chart illustrating an example of a method 400 of installing an air-to-air heat exchanger in accordance with the present invention.

FIG. 5 is a diagram illustrating an example of a template 500 in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 2 shows a perspective view that illustrates an example of an electronics cabinet 200 in accordance with the present invention. As described in greater detail below, the present invention eliminates the difficulties normally associated with retrofitting an existing cabinet to include an air-to-air heat exchanger by attaching the heat exchanger to the exterior of the cabinet.

As shown in FIG. 2, cabinet 200 includes a bottom surface 210, a top surface 212, a number of side wall surfaces 214, including a mounting side wall surface 214A, that are connected to bottom surface 210 and top surface 212, and a door 216 that is connected to a side wall surface 214 via hinges or other structures that allow an interior of cabinet 200 to be exposed.

When door 216 is closed, the interior of cabinet 200, as defined by bottom surface 210, top surface 212, side wall surfaces 214, and door 216, becomes an air tight and water tight enclosure. In addition, cabinet 200 includes a rack 218 that lies inside cabinet 200 and holds telecommunication equipment 218A.

In accordance with the present invention, mounting side wall surface 214A of cabinet 200 includes one or more air inlet openings 220A that extend through mounting side wall surface 214A, and one or more air exit openings 220B that also extend through mounting side wall surface 214A. The FIG. 2 example illustrates three air inlet openings 220A that each have a diameter of, for example, 8.890 cm (3.50 inches), and one air exit opening 220B that has a diameter of, for example, 13.335 cm (5.25 inches).

As described in greater detail below, the hot air in cabinet 200 is pulled out of cabinet 200 through air exit opening 220B, while cooler air is discharged into cabinet 200 through the air inlet openings 220A. (Alternately, the hot air can be pulled out of cabinet 200 through openings 220A and discharged back into cabinet 200 through opening 220B.)

In addition, mounting side wall surface 214A includes a number of first mounting holes 220C that extend through mounting side wall surface 214A around the air inlet openings 220A, and a number of second mounting holes 220D that extend through mounting side wall surface 214A around air exit opening 220B. The first and second mounting holes 220C and 220D can have diameters of, for example, 0.635 cm (0.25 inch).

In further accordance with the present invention, cabinet 200 includes a gasket 230, a gasket 232, and an air-to-air heat exchanger 234. Gasket 230 has a first air opening 230A that extends through

gasket 230 and surrounds the number of air inlet openings 220A that are formed in mounting side wall surface 214A, and a number of first mounting holes 230B that extend through gasket 230 and correspond with the number of first mounting holes 220C that are formed in mounting side wall surface 214A.

Gasket 232 has a second air opening 232A that extends through gasket 232 and surrounds the number of air exit openings 220B that are formed in mounting side wall surface 214A, and a number of second mounting holes 232B that extend through gasket 232 and correspond with the number of second mounting holes 220D that are formed in mounting side wall surface 214A. Gaskets 230 and 232 can both be implemented with, for example, silicon rubber gaskets.

Air-to-air heat exchanger 234, in turn, includes a back plate 240, a front plate 242, and a number of side walls 244 that are connected to front plate 240 and back plate 242. Back plate 240 has a number of air exit openings 240A (one is shown in the example) that accommodates the number of air inlet openings 220A in mounting region 220.

In the FIG. 2 example, air exit opening 240A has a height that is slightly larger than the diameter of an air inlet opening 220A. In addition, air exit opening 240A has a width that is greater than 3X the diameter of an air inlet opening 220A (since three air inlet openings 220A are shown in the FIG. 2 example).

In addition, back plate 240 has a number of air inlet openings 240B (one is shown in the example) that accommodates the number of air exit openings 220B in mounting region 220. In the FIG. 2 example, air inlet opening 240B has a diameter that is substantially equal to the diameter of air exit opening 220B.

Further, back plate 240 has a number of first mounting holes 240C that extend through back plate 240 around the air exit openings

240A, and a number of second mounting holes 240D that extend through back plate 240 around air inlet opening 240B. The first and second mounting holes 240C and 240D can have diameters of, for example, 0.635 cm (0.25 inch).

In addition, although not shown in FIG. 2 (see FIG. 3), front plate 242 includes a number of air inlet openings and a number of air exit openings. Heat exchanger 234 can be implemented with a conventional air-to-air heat exchanger, such as the air-to-air heat exchanger described in U.S. Patent Application No. 10/692,393 filed on October 23, 2003, which is hereby incorporated by reference.

As shown in FIG. 2, air-to-air heat exchanger 234 is mounted to mounting side wall surface 214A of cabinet 200 via gaskets 230 and 232 and a number of fasteners that pass through all or portions of first mounting holes 220C, 230B, and 240C, and through all or portions of second mounting holes 220D, 232B, and 240D. The fasteners can be implemented with, for example, #10 10-32 metal mounting screws and #10 flat head mounting washers.

In operation, hot air from the telecommunication equipment 218A rises to the top of the enclosure, where a fan in air-to-air heat exchanger 234 pulls the hot air into heat exchanger 234 via air exit opening 220B. As the air passes through heat exchanger 234, the air transfers heat to one side of a cooler common metal wall in heat exchanger 234. The cooler air is then exhausted into cabinet 200 via the air inlet openings 220A.

At the same time, a stream of external air is pulled in from the outside through the air inlet opening in front plate 242 via a fan in air-to-air heat exchanger 234, and across an opposite side of the common metal wall where heat from the common metal wall is transferred to the

cooler outside air. The warmer air is then exhausted back outside via the air exit opening in front plate 242.

Although FIG. 2 illustrated air-to-air heat exchanger 234 mounted to a side wall 214, heat exchanger 234 can alternately be mounted on other surfaces, such as door 216. FIG. 3 shows a perspective view that illustrates an example of an electronics cabinet 300 in accordance with the present invention.

Electronics cabinet 300 is similar to electronics cabinet 200 and, as a result, utilizes the same reference numerals to designate the structures which are common to both cabinets. As shown in FIG. 3, electronics cabinet 300 differs from electronics cabinet 200 in that cabinet 300 utilizes a number of heat exchangers 234 (two in the FIG. 3 example), and mounts the heat exchangers 234 on door 216 rather than the side walls 214.

FIG. 3 also shows a number of air inlet louvers 310 that cover the air inlet openings of front plate 242, and a number of air exit louvers 312 that cover the air exit openings of front plate 242. As shown in FIG. 3, the air inlet louvers 310 (and thereby the air inlet openings) lie above the air exit louvers 312 (and thereby the air exit openings). One of the advantages of this arrangement is that by having the air inlet louvers 310 above the air exit louvers 312, the hot exhaust air is kept from mixing with the cool intake air. (Otherwise, the hot exhaust air would blow directly over the air inlet louvers.)

FIG. 4 shows a flow chart that illustrates an example of a method 400 of installing an air-to-air heat exchanger in accordance with the present invention. As shown in FIG. 4, method 400 begins at step 410 by identifying a mounting region on the exterior surface of an electronics cabinet to mount the heat exchanger. The air-to-air heat exchanger can be mounted to any accessible surface of the electronics

cabinet (where the mounting screws can be accessed from the interior of the cabinet).

From an installation perspective, the air-to-air heat exchanger is best located on a door due to the easy access that a door provides to both the exterior and interior sides of the cabinet. From a performance perspective, the inlet and exit openings, such as the air inlet openings 220A and air exit opening 220B, are best located so that the air inlet openings are located above the air exit opening.

The electronics cabinet, such as cabinet 200, has a small temperature gradient from the top to the bottom of approximately 2°C-3°C. As a result, by pulling the hot air out of the cabinet into the heat exchanger through air exit opening 220B, and discharging the cooler air into the cabinet through the air inlet openings 220A, the cooler discharged air helps to dilute the warmer air at the top of the cabinet.

In addition, better results can be obtained by mounting the heat exchanger on east or north facing sides in the northern hemisphere to reduce the amount of direct afternoon sunlight, and as high as possible on the electronics cabinet, or near heat generating devices such as power rectifiers, to circulate the warmest air.

The heat exchanger should also be mounted to a flat, smooth surface to insure the gaskets seal properly. Further, better results can be obtained if there is an unobstructed air flow between the internal telecommunication equipment, such as equipment 218A, and the air inlets and exits, such as the air inlets 220A and air exit 220B of, for example, approximately 10.16 cm to 15.24 cm (4 to 6 inches).

Once a mounting region has been identified, such as on a side wall 214 or a door 216 of cabinet 200, method 400 moves to step 412 to clean the surface of the mounting region. The mounting surface must

be clean to make a water tight seal against the silicon rubber gaskets on the heat exchanger.

Following this, method 400 moves to step 414 to place a template on the mounting region. FIG. 5 shows a diagram that illustrates an example of a template 500 in accordance with the present invention. As shown in FIG. 5, template 500 includes a number of air inlet openings 510 that correspond with the centers of the to-be-formed air inlet openings, such as openings 220A, and a number of first mounting openings 512 that correspond with the number of to-be-formed first mounting holes, such as mounting holes 220C.

In addition, template 500 includes a number of air exit openings 514 (one is shown in the example) that correspond with the centers of the to-be-formed air exit openings, such as opening 220B, and a number of second mounting openings 516 that correspond with the number of to-be-formed second mounting holes, such as mounting holes 220D. In the FIG. 5 example, openings 510, 512, 514, and 516 are the same size. To work with the FIG. 2 example, template 500 has three air inlet openings 510 and one air exit opening 514.

Returning to FIG. 4, once the template has been placed on the exterior surface, method 400 moves to step 416 to drill pilot holes in the exterior surface of the electronics cabinet through the template. The pilot holes, which can have a diameter of, for example, 0.308 cm (0.125 inch), are best drilled from the outside in to protect the gaskets from any rough edges due to the drilling.

The pilot holes include a number of drilled air inlet openings that correspond with the centers of the to-be-formed air inlet openings, such as openings 220A, and a number of drilled first mounting openings that correspond with the number of to-be-formed first mounting holes, such as holes 220C. In addition, the pilot holes also include a drilled air exit

opening that corresponds with the center of the to-be-formed air exit opening, such as opening 220B, and a number of drilled second mounting openings that correspond with the number of to-be-formed second mounting holes, such as holes 220D.

After the pilot holes have been drilled, method 400 moves to step 418 to remove the template, and then to step 420 to drill out the openings. The openings are drilled out by cutting, in any order, the drilled air inlet openings to form air inlet openings, such as openings 220A, the drilled air exit opening to form an air exit opening, such as opening 220B, and the first and second drilled mounting openings to form first and second mounting openings, such as openings 220C and 220.

The drilled air inlet openings are cut out to have a diameter of, for example, 8.890 cm (3.50 inches). The drilled air exit opening is cut out to have a diameter of, for example, 13.335 cm (5.25 inches). The first and second drilled mounting openings have a diameter of, for example, 0.635 cm (0.25 inch). Following the cutting, the hole edges are filed and deburred and the surface is wiped clean of any metal fragments.

Next, method 400 moves to step 422 to mount an air-to-air heat exchanger, such as heat exchanger 234, to the electronics cabinet. The heat exchanger is mounted by aligning the holes of the heat exchanger with the holes in the mounting surface of the cabinet, and then feeding the electrical cables, such as power and alarm cables, through one of the openings into the interior of the cabinet.

Following this, the fasteners, such as #10 10-32 metal mounting screws and #10 flat head mounting washers, are threaded through all of the first mounting holes, such as the first mounting holes 220C, 230B, and 240C. Similarly, the fasteners, such as #10 10-32 metal mounting

screws and #10 flat head mounting washers, are also threaded through all of the second mounting holes, such as the second mounting holes 220D, 232B, and 240D. All screws should be threaded before any of the screws are tightened, and the holes should be aligned to avoid stripping. One of the advantages of the present invention is that, because of the rigidity provided by the heat exchanger, the present invention tends to stiffen the door when the heat exchanger is mounted to a door.

Once the heat exchanger has been mounted to the mounting region, method 400 then moves to step 424 to connect the electrical cables to corresponding cables within the electronics cabinet. Method 400 of the present invention is complete when the electrical cables have been connected to cables within the electronics cabinet.

Thus, another of the advantages of the present invention is that the method of the present invention greatly simplifies the process required to install an air-to-air heat exchanger in the field. The heat exchanger can be mounted to the electronics cabinets using as few as two main round holes (inlet and exit), and a substantially fewer number of mounting holes, based on a simple template.

Another advantage of the present invention is that since the heat exchanger can be easily installed in the field in a short amount of time, heat exchangers can be installed without using a replacement door. As a result, a replacement door with a heat exchanger does not have to be customized for every cabinet type. Further, since a cabinet door does not need to be replaced, all of the issues associated with replacing a door are eliminated.

It should be understood that the above descriptions are examples of the present invention, and that various alternatives of the invention described herein may be employed in practicing the invention. Thus, it is intended that the following claims define the scope of the invention

and that structures and methods within the scope of these claims and their equivalents be covered thereby.